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(54) Television signal receiving apparatus

(57) An apparatus for receiving a television signal which is made by frequency-modulation of a video signal, is improved in that a particular band-pass filter is provided in the receiver for taking out the selected television signal. This filter is designed in such a manner as to have a center frequency shifted from a frequency FBo corresponding to the center level of the video signal towards another frequency corresponding to white-signal level, so that the effect of noise in the picture, particularly when the incoming signal is of a low intensity, is decreased. The shift may vary with signal level.

FIG. 2

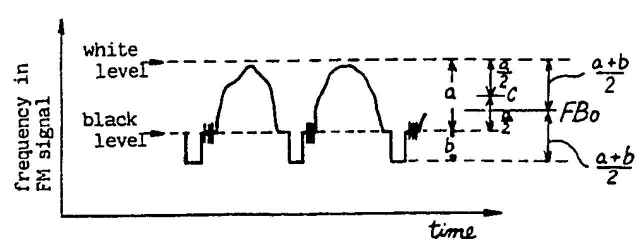

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FIG. 1

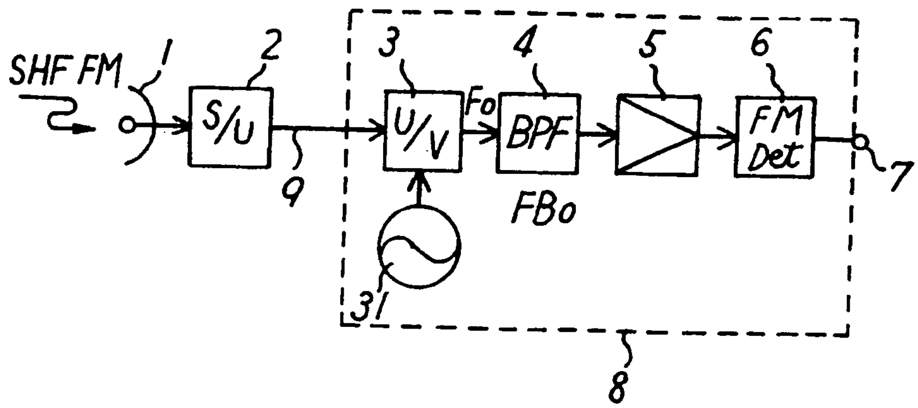


FIG. 2

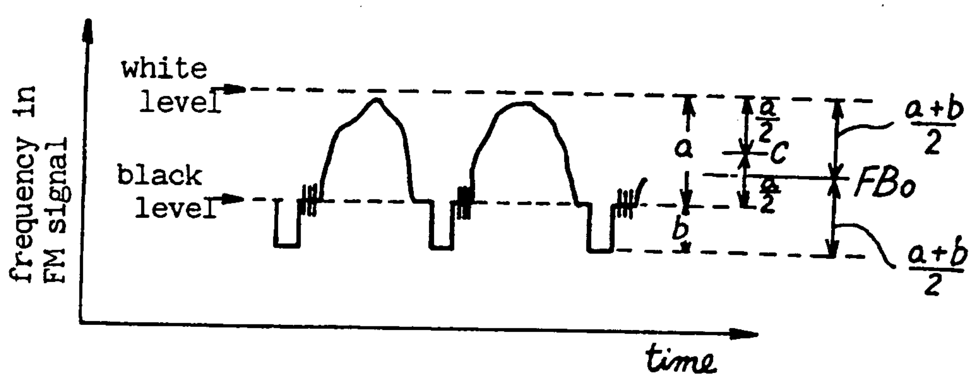


FIG. 3

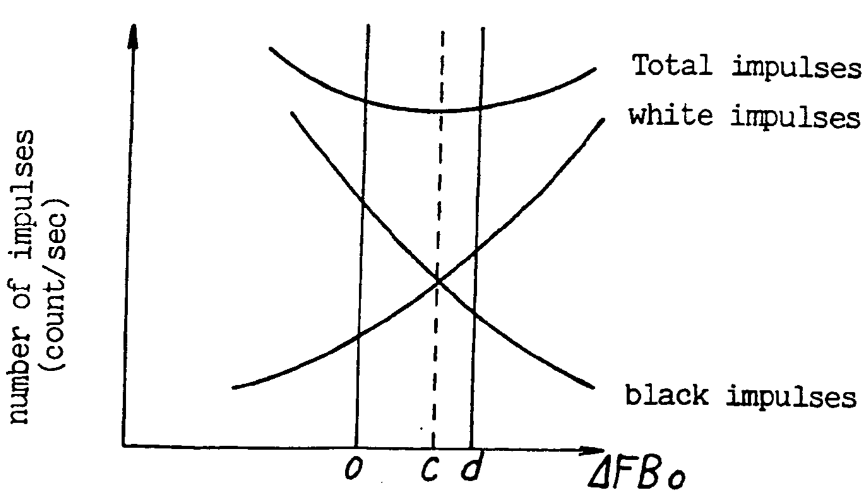


FIG. 4

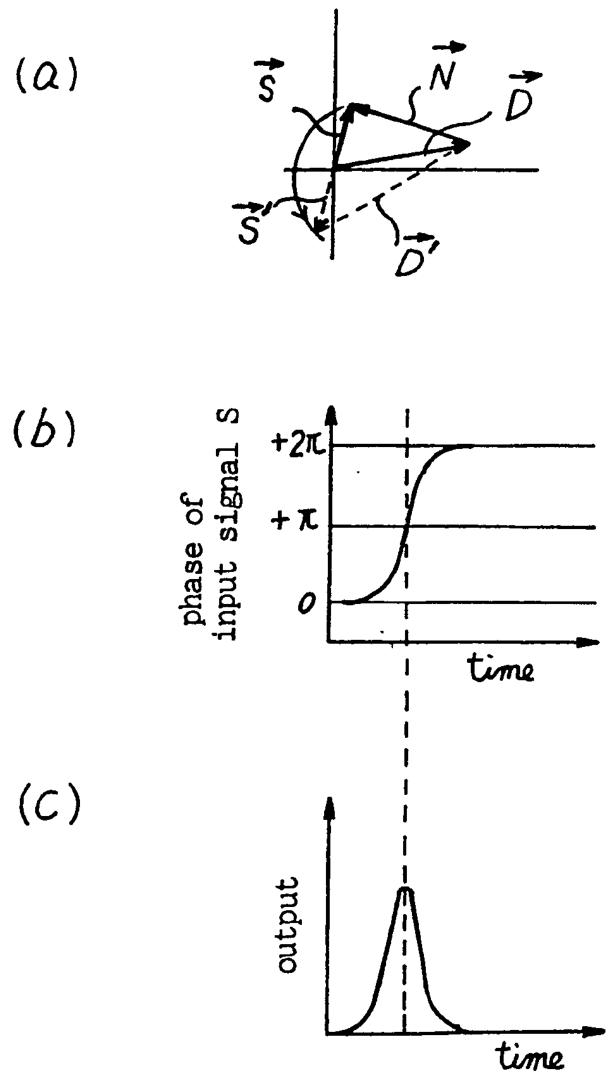

(a)
$\vec{S}$
$\vec{N}$
$\vec{D}$
$\vec{S'}$
$\vec{D'}$
(b)
phase of input signal S
+2π
+π
0
time
(c)
output
time

FIG. 5

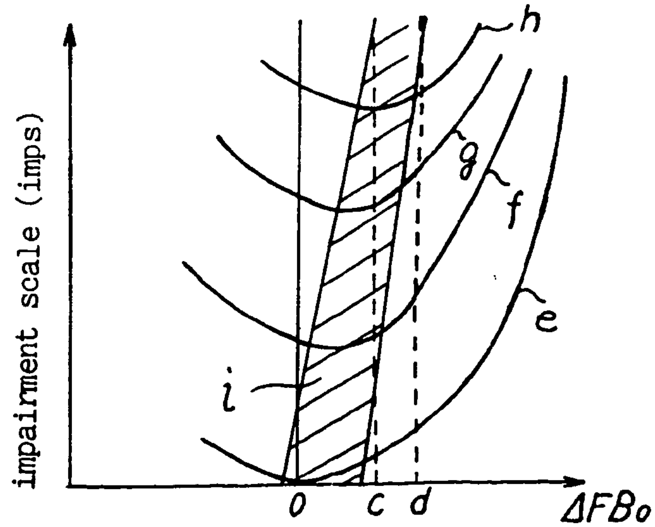

impairment scale (imps)
h
g
f
e
i
0
c
d
ΔFBo

FIG. 6

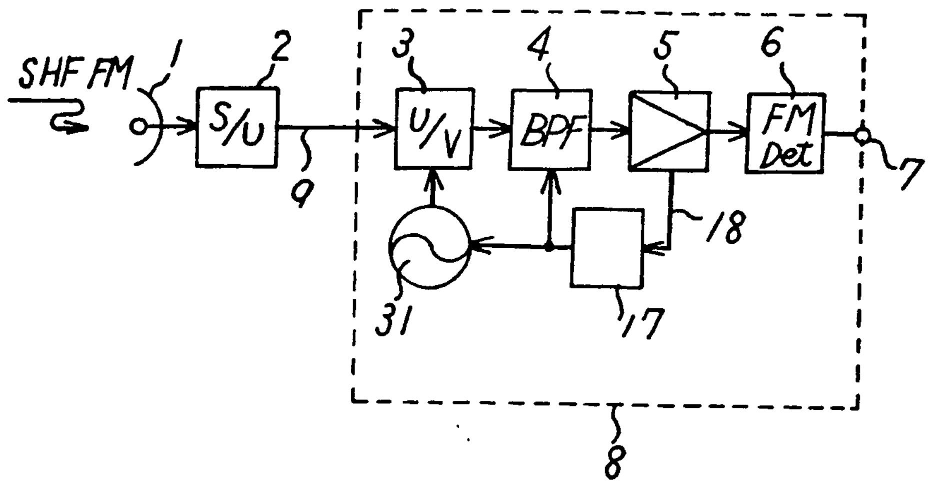
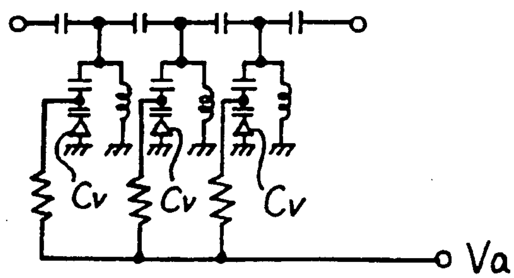

SHF FM
1
2
S/U
9
3
U/V
4
BPF
5
6
FM Det
7
18
31
17
8

FIG. 7

(a)


Cv
Cv
Cv
Va

(b)

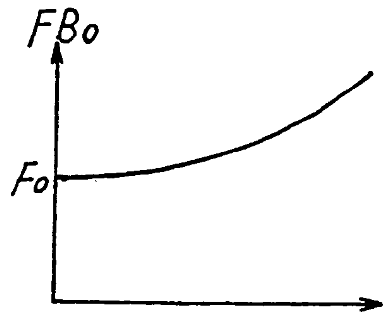
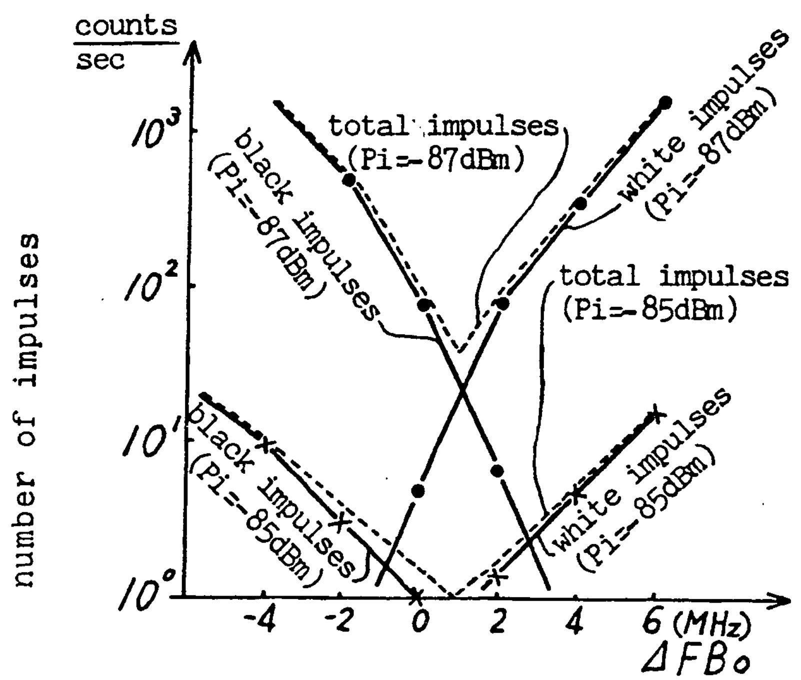

FBo
Fo
input voltage

FIG. 8

Bandwidth BW = 26MHz

OdBm = 1mW



frequency shift
towards white level

SPECIFICATION

Television signal rec iving apparatus

The present invention relates to a television signal receiving apparatus. This invention particularly concerns an improvement of a television signal receiving apparatus for receiving a television signal which is made by frequency modulation of a video signal.

In receiving and using a frequency-modulated television signal, there has been a problem that black impulse noise and white impulse noise are likely to be produced in the reproduced picture, especially when the power of the received television signal is weak. Hitherto, to the best of the Applicant's knowledge and belief, no effective measure for decreasing the effect of such noises on the reproduced picture has been proposed.

The present invention apparatus, for receiving a television signal which is made by a frequency-modulation by a video signal, having a band-pass filter for selectively taking out a selected television signal and passing it to an FM detector to issue a video signal, in which the centre frequency of the band-pass filter is selected at a value between an instantaneous frequency corresponding to the center level of the video signal and an instantaneous frequency corresponding to white signal level.

The television signal receiving apparatus particularly disclosed and illustrated in the present specification is suitable for receiving a television signal which is made by frequency modulation of a video signal, and gives improved picture quality. Accordingly, such apparatus is suitable for use in a television signal relaying or transmission system, and in particular, in a satellite television broadcasting system.

The invention will be better understood from the following non-limiting description of examples thereof given with reference to the accompanying drawings in which:-

Figure 1 is a circuit diagram showing general construction of known television signal receiver for elucidating principle of the present invention.

Figure 2 is a waveform diagram showing waveform of a video signal.

Figure 3 is a graph showing a general relation between noises of the picture and shifting of the centre frequency of a band-pass filter, of a television signal receiving apparatus.

Figure 4(a) is a vector diagram for elucidating an effect of noise to the video signal.

Figure 4 (b) and *Figure 4(c)* are time charts to elucidate generation of a noise in the video signal.

Figure 5 is a graph showing relations between frequency shifts $\triangle$ FBo of the center frequency of a band-pass filter of a television signal receiving apparatus and impairment scales of the reproduced picture.

Figure 6 is a circuit diagram showing an example of television signal receiving apparatus, embodying the present invention.

Figure 7(a) is an example of a band-pass filter in the television signal receiving apparatus.

Figure 7(b) is a graph showing relation between the center frequency and an AGC voltage of the apparatus of Figure 6.

Figure 8 is a graph showing experimental date of noises of the picture and shifting of the center frequency of a band-pass filter, of one example of the present invention.

First, the principle underlying the present invention is elucidated with reference to Figures 1 to 5. Figure 1 shows a general arrangement of a known satellite television signal receiver, wherein the output terminal of a parabolic antena 1 disposed outdoor is connected to the input terminal of an SHF-UHF converter 2, which converts the SHF television signal into UHF television signal and passes it through an UHF cable 9 to the input terminal of a UHF-VHF converter, i.e., a second frequency converter 3 in an indoor unit 8. The second frequency converter 3, utilizing the output signal of a local oscillator 31, converts the UHF signal into a signal Fo of a second intermediate frequency (herein after II-IF) and passes it through a band-pass filter 4 to a second intermediate frequency (herein after II-IF) amplifier 5. The II-IF amplifier 5 is a known automatic-gain-controlled amplifier and amplifies the II-IF signal of the FM signal and passes the resulting signal to a known FM detector 6 comprising a known limiter and discriminator. The FM detector detects the II-IF signal and issues detected multiple signals consisting of a video signal and a sound subcarrier signal to the output terminal 7.

In the abovementioned construction, according to known Carson's rule of FM modulation, the following equations hold:

$$FBo = Fo \qquad \text{........... (1)}$$

and

$$B = 2\,(\triangle F + fm) \qquad \text{........... (2),}$$

wherein,

Fo is the second intermediate frequency (II-IF),

fm is the maximum frequency component included in the video signal,

$\triangle$ F is the maximum frequency shift of FM signal,

FBo is the center frequency of the band-pass filter 4,

B is the bandwidth of the FM signal.

In the conventional system the television signal receiving apparatus for receiving the FM television signal

However, the inventor empirically found that the effects of noise in the reproduced picture are decreased when the center frequency FBo is shifted from II-IF Fo, which is a frequency corresponding to the center level of the video signal, towards another frequency which corresponds to an instantaneous frequency of white-signal level.

The principle of the present invention is now further elucidated. The television carrier is modulated by a modulating signal consisting of a picture signal component and a synchronization signal component as shown in Figure 2. The ratio of the maximum frequency deviation "a" (corresponding to a change from black level to white level) for the video signal component and the frequency deviation "b" for the synchronization signal component is selected to be 7 : 3. As shown in Figure 2, the instantaneous levels of the video signal correspond to instantaneous frequencies of the FM signal of II-IF. In the conventional receiving apparatus, the center frequency FBo of the band-pass filter 4 is selected at the frequency that is the center of sum of frequency deviations of a + b. Accordingly, the filter center frequency FBo lies, not at the center of the video frequency deviation "a", but rather nearing to the side corresponding to black level, by a shift of frequency of 3/14 x a.

In receiving satellite broadcasting, the input SHF signal is not sufficiently strong, and therefore, the receiving of the frequency-modulated FM signal is made at the vicinity of its FM threshold level, namely at the condition where carrier/noise ratio is small. As is well known, when one is so receiving the FM signal at the vicinity of the threshold level, there are problems of triangular noise and impuse noise which are particular to FM. Especially, at the vicinity of the threshold level, the impulse noise rapidly increases as the power of the input signal becomes smaller. On the picture, the influence of the impulse noise results in the generation of black impulse noises and white impulse noises. The relation between the extent of shifting Δ FBo of the band-pass filter center frequency FBo and the numbers of black noise impulses, white noise impulses and their total are shown in Figure 3. As shown in Figure 3, at the zero frequency shift (ΔFBo = 0), corresponding to the conventional television receiving apparatus location of the central frequency FBo, the black impulse noise is greater to the white impulse noise. On the other hand, numbers of both the black noise impulses and the white noise impulses are relatively small, and also the total thereof is minimum at a frequency shift of ΔFBo = c, that is to say, when the center frequency FBo of the band-pass filter 4 is selected at the center of the frequencies corresponding to the white level and black level of the video signal, as shown by Figure 2.

The inventor empirically found that the best result in decreasing the noises in picture is obtained at a further shift to ΔFBo = d of the center frequency FBo of the band-pass filter 4. A picture having the lowest noise is obtainable by selecting the center frequency FBo to be a frequency which is nearer to the frequency corresponding to the white level, in other words, a frequency exceeding the center frequency c of the frequency range "a" for the picture signal. This action is based on the proposition that average human eye would notice the black impulse noises more than the white impulse noises.

The reason for the generation and nature of the impulse noises induced in the video signal can be explained as follows:

The genuine video signal and noise can be shown by a vector diagram as shown in Figure 4(a), wherein $\vec{D}$ represents a vector of the geniune video signal, $\vec{N}$ represents that of a noise such as thermal noise in the receiving apparatus and $\vec{S}$ represents that of composite vector of the vectors $\vec{D}$ and $\vec{N}$. As the time passes, the thermal noise vector changes its length and direction, for example, to that shown by the dotted line arrow $\vec{D}'$. Accordingly, the composite vector changes from $\vec{S}$ to $\vec{S}'$ as shown in Figure 4(a), and during the change that tip of the vector moves around the origin point of the vector D by changing the vector direction by 2 ↑ C. Since the output of FM detector 6 is proportional to time differential of the instantaneous phase of carrier, the abovmentioned 2 ↑ C change of the composite vector produces an impulse noise shown by Figure 4(c) and the impulse forms black or white noise.

In order to suppress such impulse noises, hitherto there have been proposed an FM feedback demodulation system, a phase lock demodulation system and a multiple loop feedback FM demodulation system. However, such systems require very complicated circuit arrangements, and therefore make the receiving apparatus much too expensive for a satellite direct receiving TV set for domestic use.

Next, picture impairment scale due to factors other than the impulse noise characteristic, for example, differential gain and differential phase of the video signal, residual buz noise and distorsion of synchronizing signal has the characteristics as shown by a curve e of Figure 5 which shows relation between the center frequency shift and the impairment scale. As shown by the curve e, the picture impairment scale becomes worse as the shift of the central frequency of the band-pass filt r from the center frequency of the frequency ranges a + b of Figure 2 increases. This is caused by the known group delay characteristic of a band-pass filter. Curves f,g and h of Figure 5 show total picture impairment characteristics including the abovementioned impuls noise characteristic, wherein curv s e to h are curves at varying input video signal power intensities. As shown by these curves, as the input tel vision signal power becomes smaller, the impairment scale becomes worse. Also, the condition for obtaining a minimum impairment scale shifts from the condition of ΔFBo = o to the condition of ΔFBo = c or ΔFBo = d.

Summarising the above, th shift of the center frequency should be greater towards the white level frequency as the input television signal is smaller, and for a sufficiently large input television signal the condition of ΔFBo = O of the conventional apparatus is acceptable.

Accordingly, in an apparatus for receiving a television signal which is made by a frequency-modulation by

a video signal, the improvement disclosed herein can be summarised as that a band-pass filter provided in the receiver for selectively taking out the video signal has a center frequency which is selected between an instantaneous frequency corresponding to the center level of the video signal and another instantaneous frequency corresponding to white-signal level.

A preferred embodiment of the present invention is now described with reference to Figures 6 and 7.

In the circuit shown in Figure 6, the output terminal of a parabolic antena 1 disposed outdoors is connected to the input terminal of an SHF-UHF converter 2, which convert the SHF FM television signal into a UHF FM television signal and passes it through an UHF cable 9 to the input terminal of a UHF-VHF converter, i.e., a second frequency converter 3 in an indoor unit 8. The second frequency converter 3, utilizing the output signal of the local oscillator 31 converts the UHF signal into a signal Fo of a second intermediate frequency (II-IF) and give it through a band-pass filter 4 to a second intermediate frequency (II-IF) amplifier 5. The II-IF amplifier 5 is a known automatic-gain-controlled amplifier and amplifies II-IF signal and passes the resultant signal to a known FM detector 6 comprising a known limiter and discriminator. The FM detector 6 detects the II-IF signal and issues a detected multiple signal consisting of a video signal and a sound subcarrier signal to the output terminal 7. The II-IF amplifier 5 also gives a signal, which corresponds to the input signal power level, through a connection 18 to a voltage control circuit 17. The voltage control circuit 17 feeds control voltages to the band-pass filter 4 and to the local oscillator 31, in order to cause the band-pass filter 4 to change its center frequency and to cause the local oscillator 31 to change its oscillating frequency. Figure 7(a) shows one example of a circuit construction of a known band-pass filter 4, where variable capacitance diodes Cv are connected in series to capacitors of each of tank circuits, and a bias voltage is impressed onto the variable capacitance diodes Cv from a bias voltage terminal Va. The band-pass filter 4 shows the characteristic curve as shown by Figure 7(b), wherein the abscissa indicates the bias voltage and the ordinate indicates the change of the center frequency FBo. By means of the voltage change at the connection 18, the characteristic of the band-pass filter 4 is controlled in such a manner that the frequency shift of the center frequency is made in response to the intensity of the input television signal in the hatched area in Figure 5. The oscillation frequency of the local oscillator 31 of the second frequency converter 3 is also controlled by other variable capacitance elements in such a manner that oscillation frequency selection can be made easily by application of control voltage by the voltage control circuit 17.

Figure 8 shown curves of measured relations between the frequency shift ΔFBo of the center frequency FBo towards the white level of the band-pass filter 4 of an embodiment Figure 6 and counts of white impulse noise, black impulse noise and the total thereof. In the embodiment, the bandwidth "a" of the video signal is 12MHz and the bandwidth BW of the band-pass filter 4 is 26MHz. The parameter which is varied is the input power Pi of the television signal. As Figure 8 shows, the best performance with respect to noise is obtainable when the frequency shift Δ FBo is between 1 to 1.5 MHz towards the white level side. By the shifting of the center frequency FBo, the C/N (total count of noise impulses) figure is improved to avalue equivalent to that resulting if the apparatus received a television signal of a power 1 to 2 dB stronger than it actually receives.

By selecting the center frequency of the band-pass filter in a specified manner, a receiving apparatus in accordance with the present invention is capable of reproducing the picture with decreased noise. Therefore lowest practical input television signal for enabling direct receiving of a satellite broadcast is 1 to 2 dB lower than that needed in the prior known and conventional apparatus. This enables use of smaller parabolic antena and the use of receiving sets with a higher noise figure, and hence will enable mass production of a cheaper receiving apparatus than the conventional one.

CLAIMS

1. Apparatus, for receiving a television signal which is made by a frequency-modulation by a video signal, having a band-pass filter for selectively taking out a selected television signal and passing it to an FM detector to issue a video signal, in which the center frequency of the band-pass filter is selected at a value between an instantaneous frequency corresponding to the center level of the video signal and an instantaneous frequency corresponding to white signal level.

2. Apparatus in accordance with claim 1, including a frequency converter containing a local oscillator, the oscillation frequency of which is adjusted in response to the intensity of the television signal received by the apparatus.

3. Apparatus in accordance with claim 1 or 2, in which the band-pass filter comprises resonance circuits containing variable capacitance elements, and a control circuit to impress a voltage responding to the intensity of the input television signal on said variable capacitance elements.

4. Apparatus in accordance with claim 2 or 3, in which the local oscillator comprises variable capacitance elements, and a control circuit to impress a voltage responding to the intensity of the input television signal on said variable capacitance elements.

5. Apparatus according to any one of claims 1, 2, 3 and 4 in which the maximum frequency shift of said center frequency is selected to be substantially 3a/14, where "a" is the maximum frequency deviation of the picture signal.

6. Television receiving apparatus substantially as herein particularly described with reference to and as illustrated in Figures 3-8 of the accompanying drawings.

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